(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
31 May 2001 (31.05.2001)

PCT

(10) International Publication Number
WO 01/37945 A2

(51) International Patent Classification[7]: A63B 43/00

(21) International Application Number: PCT/US00/41923

(22) International Filing Date:
6 November 2000 (06.11.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09/449,257 24 November 1999 (24.11.1999) US

(71) Applicant and
(72) Inventor: SITRICK, David [US/US]; 820 Burchell, Highland Park, IL 60035 (US).

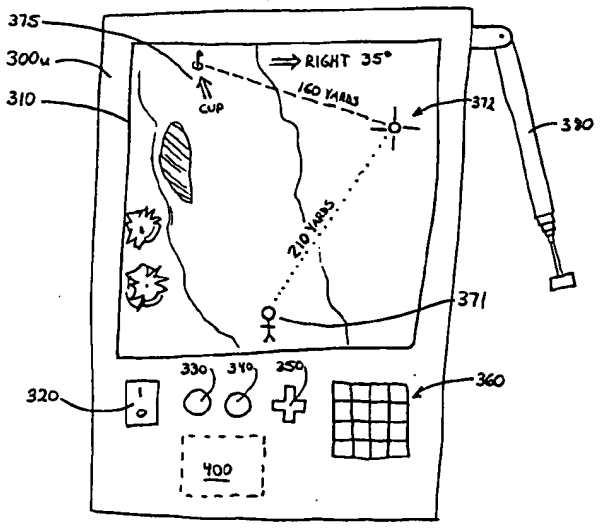
(81) Designated States *(national)*: CA, JP.

(84) Designated States *(regional)*: European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR).

Published:
— *Without international search report and to be republished upon receipt of that report.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: METHODOLOGY, ASSEMBLY, AND SYSTEM FOR TRACKING PLAYING DEVICE HAVING DETECTABLE SIGNATURE



(57) Abstract: An assembly, system and methodology for tracking a playing device (e.g., a golf ball, a tennis ball, a baseball, a football, a hockey puck, a badminton bird, a soccer ball) having a detectable signature within a play field, for improving speed and quality of play. The apparatus is tracked by active or passive means, and a display presentation is generated and displayed for a user. The invention provides for reverse-channel communication with the playing device, thus permitting the device to change physical characteristics such as center of gravity and moment of rotational inertia while in motion at the direction of the user. The invention also provides for positive identification of scoring information, even when the actual playing device may be hidden from direct view.

WO 01/37945 A2

METHODOLOGY, ASSEMBLY, AND SYSTEM FOR TRACKING PLAYING DEVICE HAVING DETECTABLE SIGNATURE

RELATED APPLICATIONS

Not Applicable.

FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not Applicable.

BACKGROUND OF THE INVENTION:

This invention relates to a methodology and the apparatus and system associated therewith for tracking position and/or movement of a game playing piece, such as a golf ball, tennis ball, baseball, football, hockey puck, badminton bird, soccer ball, etc.

In conventional play, it is common to have loss of the playing piece. For example, in the game of golf, players frequently hit their golf balls out of their visual line of sight, or otherwise lose sight of the golf ball. This results in a delay in the game as the golfer and/or caddie are required to go searching for the ball wherever it was played. This delays other players who may be waiting to tee off from progressing through the course. Although this is merely an inconvenience for amateur golfers, for golfers aspiring to be professional golfers, this delay can be intolerable.

Previous solutions to this loss problem have involved highly reflective or florescent paint schemes on the golf ball to impart high visibility. This only works if the golf ball has landed somewhere where it is visible to observers that are searching for it. Very tall grass or other natural obstacles such as rocks or trees that may obscure the view of the golf ball render the prior inventions useless. Often, this results in total loss of the golf ball and having to in addition lose a stroke and throw a new ball. Similarly, in soccer, balls are often kicked into woods or out of sight. Similarly, in golf, balls are hit into high grass or wooded areas and are lost. In other games, the same things happen.

In addition, the present invention finds application in the broadcast of the sports event, and can be used to provide a visual display presentation of the game piece (ball/puck/bird/etc.), for one or all players, and can also provide the capability for speed and trajectory tracking, useful for commentary and broadcast television.

SUMMARY OF THE INVENTION:

In accordance with the present invention, a methodology and system therefore provide for placing a detectable signature on a game play piece for use by a player/user (e.g., a golf ball), sensing the game play piece position relative to the user, and displaying the relative position of the game play piece.

The present invention utilizes a signature detection technique which permits tracking a playing device (e.g., a golf ball) that has been played. In one embodiment, the manufacturer of the golf ball builds a custom (serialized or numbered) golf ball for a specific player (the user). The can assign a separate identification number for each of a plurality of signatures. The system of the present invention can use radio isotopes or magnetic flux densities or radio transmitters to "tag" each golf ball utilizing unique signatures which permits a plurality of encodings to be performed.

For example, choosing a selection of seven unique signatures provides for a total of 128 unique addresses, wherein the presence or absence of each signature determines a logical bit in an encoding number. There are thus 128 different combinations of presence or absence of the signature. In this embodiment, one encoding, namely that being no signature present, would be indistinguishable from a conventional prior art golf ball. Therefore, the maximum number of practical encodings realized in this example of the present invention would be 127.

A small hand-held detector, possibly with a display of some sort, like an LCD display, would allow the user to narrow in and locate a golf ball that has been struck, even if it has landed off-course. This detector device may optionally, in another embodiment, be integrated with a larger display system mounted on a golf bag or a golf cart. In one embodiment, the larger system is more sensitive and be able to resolve the location of the ball at a significantly larger range than that of the hand-held device. The hand-held device would then be used to find the actual location of the ball once the user had located the gross area where the ball should be.

Alternatives to the radio isotopes and magnetic encoding (where the presence of magnets and particular orientations provide a magnetic field that can be detected at some distance) and radio frequency transmitters (where the radio frequency transmitter will emit a locating signal on a particular frequency - the frequency corresponding to the unique address for this particular golf ball for the user), includes passive components which are externally activated to give off a signature.

These and other aspects and attributes of the present invention will be discussed with reference to the following drawings and accompanying specification.

BRIEF DESCRIPTION OF THE DRAWINGS:

FIG. 1 illustrates a construction of a game playing piece having a detectable signature layer deposited or otherwise affixed within the construction of the playing piece, in accordance with the present invention;

FIG. 2 provides an alternative embodiment of FIG 1 of a structure placing a detectable signature layer atop the game playing piece, in accordance with the present invention;

FIG. 3A illustrates one encoding of a 32-bit ID signal, in accordance with the present invention;

FIG. 3B illustrates an alternative encoding of a 32-bit ID signal, in accordance with the present invention;

FIG. 4 illustrates all practical unique encodings of a 5-bit ID signal, in accordance with the present invention;

FIG. 5 illustrates an embodiment of a device that can alter its center of gravity, in accordance with the present invention;

FIG. 6 illustrates an embodiment of a device that can alter its rotational moment of inertia, in accordance with the present invention;

FIG. 7 illustrates a user display system which provides the user with a visual display presentation, in accordance with the present invention;

FIG. 8 illustrates a vehicle–mounted display, such as a golf cart, in accordance with the present invention;

FIG. 9 illustrates a status display, such as in a central monitoring location, in accordance with the present invention;

FIG. 10 is a system block diagram of the architecture for the display system, with alternative embodiments shown in dashed boxes, in accordance with the present invention;

FIG. 11 illustrates a first alternate embodiment of the detection and display system in accordance with the present invention;

FIG. 12 illustrates an alternative embodiment of the detection and display system in accordance with the present invention;

FIG. 13 illustrates another alternative embodiment of the detection and display system in accordance with the present invention;

FIG. 14 illustrates an alternate embodiment of separated sensing and display systems, in accordance with the present invention; and

FIG. 15 illustrates a score detection embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT:

While this invention is susceptible of embodiment in many different forms, there is shown in the drawing, and will be described herein in detail, specific embodiments thereof with the understanding that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the invention to the specific embodiments illustrated.

FIG. 1 illustrates a construction of a game playing device assembly, illustrated as a ball (such as a golf ball) having a detectable signature layer deposited or otherwise affixed to the playing piece, in accordance with the present invention. The playing

device assembly can also be a puck, a bird, a baseball, a softball, a football, a soccer ball, etc.

Referring to FIG. 1, there is illustrated the construction of a game playing piece, illustrated as a golf ball, constructed to provide for a detectable signature. The game playing piece **100** is comprised of a core, such as a ball or puck **110**, to which a detectable signature layer is adhered. In a preferred embodiment, protective coating layers **120** placed between the core of the ball **110** and the detectable signature layer **130** and second protective coat layer **140** on the other side of the detectable signature layer **130**, to which a conventional outer layer cover of the game playing piece or ball is adhered. The detectable signature layer can be comprised of a magnetic flux-based layer or coating, which has a defined flux density, or of one or a plurality of magnets.

By providing a plurality of detectable different flux density coatings or magnets, and then labeling the conventional outer cover with an indication of the unique reference number for that playing piece (e.g., ball), a large number of unique player signatures can simultaneously be utilized. Any type of detectable signature layer is acceptable. These include magnetic material and coatings, low radiation-based radio-isotopes (where the levels are non-harmful to humans), etc. All original remnants and elements of the game playing piece design must be retained. The insertion of a detectable signature layer therewithin must be non-intrusive of any of the physics of operation of the game piece. Thus, the weight and balance and spin of a game playing piece (e.g., golf ball) must not be altered. The design must be modified to compensate for any changes introduced by the signature layer. However, in the preferred embodiment, where magnetic flux is detected, and the detectable layer is within the construction of the conventional golf ball, no new design is necessary.

Referring to FIG. 2, an alternate embodiment is illustrated, wherein the core **210** has a conventional outer layer covering **250** thereupon. A detectable signature layer **230** is placed atop the outer layer covering **250**. This detectable signature layer **230** can be detectable magnetically, electrically, or optically (e.g., such as paint or reflective tape atop the ball's outer surface), with passive (externally activated and/or detected) and active (e.g., magnets or signal transmitter) signatures.

There are technical difficulties that need to be addressed. The additions to the balls of the detectable signature must not disturb the balance of the ball (which affects its spin and flight), and also the playability of the ball (how much it deforms under impact and whether that deformation is uniform). Design attention must be given to assure that the game playing piece is not affected negatively by the addition of a detectable signature, such as by the insertion of a small micro-transmitter inside the ball. Also, the amount of shock, that is mechanical shock, that is applied to the ball (golf ball, baseball, etc.) is significant. Certain types of detectable signature solutions will therefore require impact-resistant housing, or an impact-resistant construction of the device.

The output power requirements for a radio transmitter are not significant. It would not be necessary to detect the golf ball generally in excess of 500 yards, and the necessary detection range might be significantly smaller in practice. Given that a golf ball (as are many other playing devices) is a sealed assembly, the inability to replace the power source is a problem. One possible solution is to have the device constructed so that it only powers the transmitter for a short period of time after the ball is struck (e.g., 30 minutes) after which the transmitter shuts itself off. Alternatively, the transmitter can go into a different kind of locating mode where it conserves power by signaling less frequently. The opposite operation might be useful too, that the ball transmits intermittently, a chirp or other identification, audible and/or inaudible, at preset intervals after being struck for some amount of time. For example, the ball might be struck and then proceed to transmit, at 5 second intervals, the necessary signal to find the ball, and continue this pattern for the time period of the next hour.

Magnetic fields are difficult to sense, given the rate at which the magnetic field strength drops off with distance. In one embodiment of the present invention, passive circuits such as those used in building and merchandise security systems are used, such as where a small tank circuit, or other inductive loop, or other means is embedded within the golf ball. Then, the searching mechanism, comprising a transmitter, transmits a field which is disturbed by the passive device in the golf ball, thereby allowing the detection device to detect the golf ball. The total amount of range and power output of the transmitter are design decisions.

In another embodiment, passive circuits are embedded within the golf ball. Two (or more) radio transmitters output signals which generate a beat signal off the golf ball which is then detected to determine and display position.

There are many options for the user of wireless transmitter. A transmitter can encode a detectable signature as an identification signal of realistically any length. FIG. 3A illustrates one encoding of a 32-bit ID signal, in accordance with the present invention. In the illustrated example, a 32 bit encoded signature **1010** can be transmitted that would uniquely identify one in 4 billion users, which conceivably would support any realistic number of golfers.

FIG. 3B illustrates an alternative encoding of a 32-bit ID signal, in accordance with the present invention, where the 32 bit address space is divided into a 24 bit user identification **1040** and an 8 bit individual ball identification **1050**. This division allows for 16 million different users, each with the ability to have 256 unique ball numbers associated with them. This alternative encoding system could be used for authentication in golf matches, or other ball games, to make sure that there was not a substitution of a ball in play. In one embodiment, a serial bit stream is transmitted with or without error correction or redundant information. In the preferred embodiment, a serial bit stream is

transmitted with error correction and redundant information to improve the robustness of communication and reduce the occurrences of false detections and identifications.

In accordance with another methodology, the transmitter transmits simultaneously on a number of distinct frequency bands, the presence or absence of the signal in each frequency band, giving a number of discernable signatures equal to 2^n-1, where n is the number of individual frequencies in use. For example, with 5 frequencies in use, 2^n is 32. Subtracting the one case of all frequencies being off (i.e., indistinguishable from a prior art golf ball and thus unable to be located) reveals that there are 31 possible combinations or frequencies that would uniquely identify a golf ball in accordance with the present invention. FIG. 4 illustrates all the practical unique encodings of an ID signal with 5 frequencies in use, in accordance with the present invention. Given the center frequencies f_1, f_2, f_3, f_4, and f_5, the 31 possible combinations in this example embodiment are listed as shown in FIG. 4. Each frequency may encode information independently of the others; thus the ball encoding may be split among a plurality of frequency bands.

The advantage of radioactive isotopes, is that it does not require any significant change in the construction of the golf ball. The coating could actually be applied after conventional manufacturing using trace amounts of a covering. It wouldn't be necessary to alter the manufacturing steps of the golf ball significantly. Alternatively, the radioactive substance can be applied just prior to the final encasing, thereby protecting the radioactive coating from the elements, but it's still not clear that this would significantly impact the manufacturing process. The potential danger of radio isotopes requires careful investigation into safety. A sufficiently sensitive radiation detector, and sufficiently weak radiation levels, safe for humans but strong enough to be detected at 100 to 500 yards are required for the user of isotopes. Even then, significant testing must be done to determine whether or not that level of radiation corresponds to any significant health concern.

Magnetic sensing by its nature would change the construction of the golf ball somewhat in that magnetic elements would need to be embedded in the ball. However, the magnetic elements would be solid, and otherwise inert, therefore, they could probably be arranged to impart minimal differences to the playability of the ball, the compressibility of the ball, and the rotational characteristics of the ball. Alternatively, film layers of magnetic flux can be applied. By far the most difficult integration into the manufacturing process would be the inclusion of a small transmitter.

In an alternative or additional embodiment, both a receiver and a transmitter are placed in the ball, thereby making it a transceiver. The transceiver can be connected to a mechanism in the ball. Then, if after striking a ball, the golfer notices that the ball is deviating off course, the golfer can transmit a signal to the ball to cause a change to

effect its balance characteristics, thereby possibly causing it to fly in a slightly different direction by either modifying the spin or the center of gravity of the ball. In the situation of the ball heading for a water trap, any random motion on the part of the ball is probably more desirable than simply letting it fly ballistically. In fact, new games can be created allowing use of in-play ball trajectory control.

FIG. 5 illustrates an embodiment of a device that can alter its center of gravity, in accordance with the present invention. The device comprises a core **800** containing a mass **810**, a transport means for the mass, and a transceiver **880**. As shown in the illustration, one embodiment of the transport means comprises a small motor **850** axially coupled to rollers **830**, for actuating linear belt **840**. The mass **810** is coupled to the belt **840**. Thus, upon receipt of a signal via transceiver **880**, the motor **850** can variably position the mass **810** anywhere from a first position **815** to a second position **820**, thus changing the center of mass of the entire assembly within the core **800**. The position can be changed to cause the playing device (e.g., golf ball) to wobble eccentrically, thereby changing the aerodynamics and play of the device while in flight or other motion.

FIG. 6 illustrates an embodiment of a device that can alter its rotational moment of inertia, in accordance with the present invention. The device comprises a core **900** containing balanced masses **930**, **940**, a transceiver **980**, and an actuator **910**. In the illustrated embodiment, the actuator **910** is a solenoid. In operation in accordance with the present invention, the masses **930**, **940** are originally in starting positions **934**, **944**, and are retained in that position by retaining means **931**, **941** being intersected by solenoid shaft **920** in a first shaft position **924**. Upon receipt of a signal via transceiver **980**, the solenoid **910** activates and retracts shaft **920** to a second shaft position **925**.

As the shaft **920** retracts, it no longer intersects retaining means **931**, **941**, and the masses **930**, **940** are then free to translate along a radial axis outward to final positions **935**, **945** respectively. The outward translation of the balanced masses results in a changed (increased) moment of rotational inertia for the device. The player can use the system of the present invention to slow the rotation of a playing device in motion, in a fashion similar to a rotating ice skater that lets out his or her arms to slow a spin.

Referring to FIG. 7, a first embodiment of the video display system **300u**, for the user version, is illustrated. The video system **300**, and in particular the system **300u**, is comprised of a video display **310**, a plurality of switches and control inputs including on/off switch **320**, push button switches **330** and **340**, directional push button/joy stick **350**, numeric keypad and soft function keypad **360**, and control logic **400**. The visual display presentation on the video display **310** can provide a visual representation of many elements of the game, including the shape of the holes on the golf course, the location of the hole **375** relative to the position of the player **371** and relative to the player's golf ball **372**. Relative distances to the player's ball indicated as 210 yards and

to the hole indicated from the golf ball **372** as 160 yards relative to the hole **375**. An antenna or detector **380** provides for flux signature detection and/or reception.

In a preferred embodiment, video subsystem **300** comprises a commercially available lightweight liquid crystal display (LCD) display screen, such as those produced by Sony Corporation of Japan, Sharp Corporation of Japan, Hitachi Corporation of Japan, and Crystaloid Displays of Hudson, Ohio. The video display system **300u** is typically ruggedized for outdoor use as a matter of design choice.

The display presentation can be generated internally by control logic **400**. Control logic **400** comprises a display generation subsystem, which can be implemented as a custom Application Specific Integrated Circuit (ASIC) or by using commercially available general purpose embedded computer components, such as those manufactured by Motorola Corporation of Schaumburg, Illinois, Texas Instruments of Dallas, Texas, and Intel Corporation of Santa Clara, California.

Components such as the user controls **320**, **340**, **350**, and **360**, and the antenna **380**, are readily available from a large number of electronic parts suppliers, such as Rohm Electronics of Antioch, Texas, Tandy Corporation of Houston, Texas, and DigiKey Corporation of Thief River Falls, Minnesota.

Referring to FIG. 8, in an alternate embodiment, a vehicular mounted video display system **300B** is coupled in the golf cart or other vehicle to permit tracking of the player's or players' golf ball or golf balls (or other playing pieces for other games) from the vehicle. In one embodiment, the user's video system **300u** is linked into a cradle in the vehicle **390**, such as a golf cart, and either the video display **310** and/or an additional larger display (not shown) can be provided.

Referring to FIG. 9, there is shown in an additional or alternate embodiment, where a display **395** is centrally provided, of the position of players, carts, and golf balls on a golf course. The display **395** can be wall mounted, or on one or a plurality of television sets. The display **395** is hooked to a receiver **396** for receiving signals on the visual presentation data for each of the users and vehicles on the course, which couples to a CPU **397** which provides signals to the display **395** for display thereupon.

FIG. 10 illustrates a block diagram of the electronic and computing system architecture **400** for the display system **300** (or **300b**). The core elements are shown in solid lines, while elements related to alternative embodiments are shown in dashed boxes.

Referring to FIG. 10, there is illustrated the electronic system block diagram for the user display subsystem **300**. The electronic subsystem **400** is comprised of a display **460** such as a liquid crystal display (LCD), cathode ray tube (CRT), electro-luminescent, light emitting diode (LED), or even an audio-based display produced by a speaker or sounder. The display **460** can include both visual and audio, or one or the

other of visual and audio presentation outputs. A plurality of input devices, such as **320**, **340**, **350**, and **360** of FIG. 7, are coupled to the processor **410**.

Referring to FIG. 10, the processor **410** can be any microprocessor or microcomputer, including any of the commercially available 4-bit, 8-bit, 16-bit, 32-bit, and higher, chips, or a digital signal processor. The choice of processor **410** depends upon the remaining functionality of the particular electronics associated with the particular display unit **300**. Where the display system **300** includes a signature detector, the signal detection circuitry **440** is provided to permit the detection of the signature within a defined minimum range of the signal detector (such as 300-500 yards for the game of golf, ranging from 50 yards to 1000 yards for any particular game, or more or less). The signal detector provides an output signal to the processor **410** responsive to detecting the signature associated with the ball within the range of the detector. The processor is coupled to read/write RAM **420** and non-volatile memory **430**, such as ROM or EPROM. The processor **410** in conjunction with the RAM and ROM, or in the case of a single chip microcomputer, where the processor RAM and ROM are all integrated, then the microcomputer, provides for processing of the signals from the signature detector to provide for determination of relative position by computing relative position of the detectable signal relative to the position of the signature detector associated with the display and the user with the display, and the processor **410** thereafter provides an output to the display **460** to provide a display as discussed both herein and with reference to FIG. 7.

A utility subsystem **480** provides for power, clocks, and other common signals to all other components within the electronic subsystem **400**. In one embodiment, a receiver **450** is provided which permits the coupling of communications signals received from systems external to the user display **300** to be coupled to the processor **410** for processing. In the case of remote detectors, that is where the signature detector **440** is not part of the user display subsystem **300** but rather is separate, the data from the external system is communicated and coupled via the receiver **450** to the processor **410** for computing the relative position of the detected signature to the user, and to provide a display output to the display **460** to generate a display presentation thereupon. In a preferred embodiment, the receiver **450** is further comprised of a transmitter, so that the receiver/transmitter subsystem provides for the output transmission of a signal which is detected by the subsystem external to the user display **300**, wherein the external system is able to determine the position of the user device **300** emitting from the transmitter its signal, indicating its position, and wherein the data communicated back and received by the receiver **450** and coupled to the processor **410** provides for computation of relative location and positions of both the user display device **300** and the detectable signature ball position relative to one another, wherein the processor **410** provides an output to the

display **460** for display thereupon of this relative position information as discussed above with reference to FIG. 7.

The receiver/transmitter **450** of FIG. 10 are commercially available from a variety of vendors; the selection of output power, frequencies, receiver sensitivity, radio-frequency vs. infrared vs. ultrasonic vs. ultraviolet vs. microwave, etc. is a design choice based in part on the signature means of the playing device. If the design choice of signature means (e.g., **130** of FIG. 1, **230** of FIG. 2) permits, the signature detector **440** may be eliminated; alternatively, the signature detector **440** may decode and selectively respond based on the received ID signal as in FIGS. 3A and 3B. The signature detector **440** may be alternatively implemented as a software function within the processor **410**.

The processor **410** may comprise one of a large number of commercially available general purpose 4-bit, 8-bit, 16-bit, 32-bit, and higher embedded computer components, such as those manufactured by Motorola Corporation of Schaumburg, Illinois, Texas Instruments of Dallas, Texas, as Intel Corporation of Santa Clara, California. Alternatively, the processor **410** may comprise a digital signal processor (DSP) device such as those produced by Analog Devices or Norwood, Massachusetts. The selection of processor type is dictated by design choice of the desired embodiment.

In a preferred embodiment, display **460** comprises a commercially available lightweight liquid crystal display (LCD) display screen, such as those produced by Sony Corporation of Japan, Sharp Corporation of Japan, Hitachi Corporation of Japan, and Crystaloid Displays of Hudson, Ohio.

The input devices **470** are readily available from a large number of electronic parts suppliers, such as Rohm Electronics of Antioch, Texas, Tandy Corporation of Houston, Texas, and DigiKey Corporation of Thief River Falls, Minnesota.

The input devices **470** permit the user to provide selective input control for choice of features and functions, such as which of a plurality of detectable signatures to detect, which display of a plurality of displays to select from, which type of display information to provide (e.g., distance to the ball, layout of the course, ball location relative to hole layout, etc.). Additionally, in an alternate or additional embodiment, voice communications can be provided to voice communication subsystem **490** which provides both microphone and speaker interface to the user and couples these to the processor **410** for processing thereby and coupling appropriately to the receiver/transmitter **450** to permit for communications (bidirectionally, or unidirectionally) with others.

FIG. 11 illustrates a first alternate embodiment of the detection and display system, wherein the ball, as in FIGS. 1 or 2, provides a detectable signature which is detected by a portable detection subsystem (signature detector **440** of FIG. 10) via signature signal detection pathway **501** to provide the user with a visual display

presentation of the distance between the ball and the visual display system **300**, as illustrated and discussed in further detail with reference to FIG. 7.

FIG. 12 illustrates an alternative embodiment of the detection and display system as a whole, where a plurality of remote detectors **600** are buried or otherwise placed in various defined positions on the playing area, and where the ball with the detectable signature is sensed via detection pathways **501** to provide signals to a central processing subsystem **500** which then broadcasts communication of data to a user visual display system via the receiver **450** of FIG. 10.

The buried ground sensors **600** may comprise field antennas for generating (or sensing) an electric, a magnetic, or an electro-magnetic field to stimulate the signature means in the playing device. Antennas are available from a large number of manufacturers and distributors, including RSI Wireless Antennas of Des Plaines, Illinois, and AMP Corporation of Harrisburg, Pennsylvania. Alternatively, they may comprise sensitive motion and vibration detectors tuned to detect the particular type of playing device in use, or sensors to detect low-level radio-active signatures as previously described.

FIG. 13 illustrates yet another alternative embodiment wherein the ground detectors **600** of FIG. 12 are replaced with elevated imaging sensors **706** for signature detection of the ball. The elevated imaging sensors **706** have various fields of view **721**, **722** generally covering a playing area or region **701** containing the ball **100**. The elevated imaging sensors **706** provide sensed signals responsive to detecting the signature of the ball **100** and provide communication of these sensed signals to a processor **730** which processes and/or integrates the data from the imaging sensors and provides a communications output **711**, such as a wireless link, to the user's receiver **300** in the visual display system of the user, to provide a visual display presentation indicating the user's relative position to the ball.

The elevated imaging sensors **706** may comprise field antennas for generating (or sensing) an electric, a magnetic, or an electro-magnetic field to stimulate the signature means in the playing device. Antennas are available from a large number of manufacturers and distributors, including manufacturers as listed above. Alternatively, they may comprise sensors to detect magnetic flux density or radio signals or low-level radio-active signatures as previously described. In a preferred embodiment, they comprise imaging cameras, such as CCD cameras commercially available from a variety of vendors, infrared photosensors, traditional television tubes, and so forth. The images provided by the sensors are collected and analyzed by the processor **730** to determine the location of the ball **100**.

The processor **730** may comprise one of a large number of commercially available general purpose 4-bit, 8-bit, 16-bit, 32-bit, and higher embedded computer components, such as those manufactured by Motorola Corporation of Schaumburg,

Illinois, Texas Instruments of Dallas, Texas, as Intel Corporation of Santa Clara, California. Alternatively, the processor **410** may comprise a digital signal processor (DSP) device such as those produced by Analog Devices or Norwood, Massachusetts. This particular embodiment may also benefit from special purpose image processing subsystems and/or software, commercially available from many vendors, that performs image analysis on the sensed images to determine the location of the ball. The selection of processor type and image processing subsystems are dictated by design choice of the desired embodiment.

In one embodiment, the user's device **300** generates a signal which is utilized to compute relative position and to generate an accurate display presentation of the ball's position relative to the user, as well as supplemental play information. There are a wide variety of types of information that can be conveyed as supplemental play information. Examples include golf course hole layout, the distance to the putting green and/or the hole, the layout of hole, current hole number, a play field identification, the elevation of the play field or a portion thereof, and the inclination of the play field or a portion thereof, critique of technique, present club selection, and a club recommendation.

Supplemental play information may also include temporal information, such as but not limited to the current time, game time, game time remaining, quarter number, inning number, timeouts remaining. Supplemental play information may also include weather information, such as but not limited to ambient temperature, ambient wind speed and direction, weather alerts, the present air pressure and humidity. Supplemental play information may also include generic game information, such as but not limited to a game number, a match number, a set number, score information for the player and or competitors, penalty information, rule information and reference, current scorecard information, competitor status, and the round number.

Supplemental play information may also include generic course information, such as but not limited to the golf cart number, the distance to the clubhouse (from user, cart, or display), messages from the clubhouse and/or a central station, the distance to the nearest refreshment stand , the distance to the nearest rest room, and the distance to the nearest medical assistance. Additional information that may be displayed includes such things as advertising information, commercial messages, product recommendations, and so forth. Supplemental play information can be locally stored or communicated (wirelessly) and stored as needed and/or requested.

In one embodiment, the user's visual system **300** includes a GPS receiver, and the user system **300** utilizes the GPS receiver data in conjunction with the received communication of the image sensing of the signature detection to provide an accurate display presentation of the user's relative position to the respective playing piece. In an alternative embodiment, the user's device **300** generates a signal or is otherwise detectable (by a system such as in FIGS. 12 or 13) to permit the respective CPU-based

system (**500** and **730**, respectively) to compute user (and ball) position and communicate data to the user display system **300** (such as via receiver **450** of FIG. 10) for use by the processor **410** to generate a visual display for presentation on the display **460**. An additional option of voice communications with other user display subsystems **300** and/or remote people (e.g., clubhouse) can be provided with each respective user display subsystem providing a voice communications subsystem **490** providing speech/sound input/output (microphone and/or speaker) for coupling via processor **410** to receiver/transmitter **450**. The receiver/transmitter **450** may be digital or analog; if digital, then an analog to digital converter may be necessary for the voice communication subsystem **490**.

The voice communications subsystem **490** may be constructed using commercially available components. Microphone hardware is available from many vendors. Examples of such products include the model SM89 directional microphone, by Shure Brothers Inc. of Evanston, Illinois; and the ARIA(TM) Desktop Dictation Microphone, by Telex Communications Inc. of Minneapolis, Minnesota.

Audio amplifiers, including integrated circuits performing amplifier functions, are available from a variety of vendors, including Amplifier Research of Souderton, Pennsylvania; Analog Devices Inc. of Norwood, Massachusetts; Hitachi Semiconductor (America) Inc., of Sunnyvale, California; and Maxim Integrated Products, of Sunnyvale, California.

Integrated circuits performing as analog to digital converters are available from a variety of vendors, including Analog Devices Inc. of Norwood, Massachusetts; Harris Semiconductor of Melbourne, Florida; Motorola Semiconductor of Tempe, Arizona; Applied Signal Technology Inc. of Sunnyvale, California; and Maxim Integrated Products, of Sunnyvale, California.

The system can use 3D triangulation techniques as generally known in the art to compare the signals from each of the sensing means (e.g., **600**, **706**), thereby deriving the ball's position on the course. Triangulation is discussed in *1999 The ARRL Handbook for Radio Amateurs*, 76th Ed., American Radio Relay League, November 1998, ISBN 0-872-59181-6. Triangulation can be performed in the present invention by an algorithm that computes a spherical boundary relative to the respective sensor on which the ball must be present. The set of all spherical boundaries are then arranged in relation to one another using the location of the sensors, as stored in a database, as centers of the spheres. The ball's position is then determined by triangulation to be at the point of intersection of all the sets of spherical boundaries.

Other examples of 3D triangulation to determine position as known in the art include the Global Positioning Satellite (GPS) system, radio direction finders as used for aircraft and marine navigation, and sonic digitizers used to input the surface shape of

an object into a computer system which are available from various computer retailers and are sometimes used as a 3D mouse.

In an alternate embodiment, the user of the visual display system **300** of FIG. 11 calibrates the detector subsystem of the video system to a specific golf ball (or other playing piece) being utilized. Thereafter, the detector (e.g., **440** or **600**, etc.) will utilize this calibration information to be selective in detection of the golf ball, so as to distinguish between signatures. In a game such as golf, where multiple golf balls (playing pieces) are in use at the same time over the same hole (area), it is sometimes desirable to have a plurality of distinct detectable signatures, separately detectable and displayable.

In an alternative embodiment, all golf balls or playing pieces can have similar or the same signature, and the user display can provide a visual reference to provide a guide to all of the golf balls on a single visual presentation. Alternatively, or additionally, the visual system **300** can provide for user selection of track sub-selection for tracking only selected ones of the specific golf balls based on a differential detection of signatures.

In one embodiment, the transmitter of the searching system is powered off of the golf cart, and the transmitter and the detector are independent in that the detector is something that is hand-held by the user and the transmitter is on the golf cart and is beaming a signal from the golf cart to the general vicinity of the golf ball. This is analogous to the way that, in present warfare, radar targets can be illuminated from a source different from the detector. In an alternative embodiment, as shown in FIG. 14, the transmitter and the detector can be combined while still retaining the benefit of a lightweight and portable user display. As shown in FIG. 14, the ball **100** is bombarded by a field generated by transmitter **1100** on golf cart **390**. The ball perturbs the field and the reflected detection pathway **501** returns a signal to the golf cart **390** identifying the bearing and range to the ball from the golf cart. This location information is relayed from subsystem **300B** to user display subsystem **300**, typically via a wireless transmission.

The discussion herein mostly provides as examples a golf ball and the game of golf. However, the teachings herein, and the methodology and apparatus provided for herein, apply across a broad spectrum of games, including golf, tennis, baseball, football, hockey, badminton, soccer, and others. The present invention finds application both in the active integration into the playing of the game by the player of the game, or the official of the game (coach, etc.), to maintain better control and reduce lost ball and game delay situations. The present invention provides for speeding up of game play, by permitting the game players to avoid wasting time searching for their game balls. In the game of golf, this increases revenue potential for the course owners by permitting more foursomes to play per hour. From the player's perspective, it makes the game more fun, and keeps the game "hot" because the game play moves forward faster.

In some games, the mere traversal of a playing device across some boundary results in a point awarded to a player or team. In many such games, the device need not remain across the boundary. In games such as soccer, hockey, and particularly American football, it can be difficult for an observer to directly see if the playing device touched or traversed the boundary in question, particularly if one or more players may interfere with the view. As shown in FIG. 15, in accordance with the present invention, a sensing means is provided at the scoring goal of a soccer field. The sensing means illustrated comprises a plurality of sensors **1520** and an optional plurality of buried sensors **1510**, arranged around the periphery of the goal. The sensing means is linked to a processing device **1500**. In operation, the system can detect the passage of a playing device (i.e. soccer ball) through the boundary region defined by the periphery of sensors, and thus can detect a goal even if the playing device (e.g., soccer ball) is otherwise obscured from the official's view at the time. A similar apparatus may be used in other sports and games having a defined goal area or boundary to unfailingly detect if a playing device (e.g., ball) has passed the boundary in question.

From the foregoing, it will be observed that numerous variations and modifications may be effected without departing from the spirit and scope of the invention. It is to be understood that no limitation with respect to the specific apparatus illustrated herein is intended or should be inferred. It is, of course, intended to cover by the appended claims all such modifications as fall within the scope of the claims.

WHAT IS CLAIMED IS:

1. A trackable playing device assembly for use in a game in which a playing device has a set of predefined physical characteristics defined by rules of the game, and wherein as part of the play of the game the playing device is propelled within a predefined playing region relative to at least one player user's position, said assembly comprising:

a playing device conforming to the set of predefined physical characteristics;

a detectable signature associated with the playing device;

wherein the assembly as a whole also conforms to the set of predefined physical characteristics.

2. The trackable playing device assembly as in claim 1, wherein the detectable signature is embedded within the structure of the playing device.

3. The trackable playing device assembly as in claim 1, wherein the detectable signature is applied to the outer surface of the playing device.

4. The trackable playing device assembly as in claim 3, wherein a protective layer encloses the outer surface of the detectable signature.

5. The trackable playing device assembly as in claim 1, wherein:

a first protective layer encloses the outer surface of the playing device; and

the detectable signature is applied to the outer surface of the first protective layer.

6. The trackable playing device assembly as in claim 5, wherein a second protective layer encloses the outer surface of the detectable signature.

7. The trackable playing device assembly as in claim 1, wherein the detectable signature comprises active emissions of a signature signal.

8. The trackable playing device assembly as in claim 1, wherein the active emissions comprises one of a radio-frequency signal and a light signal.

9. The trackable playing device assembly as in claim 1, further comprising:

a transceiver, responsive to an external signal source; and

means to alter at least one physical characteristic of the playing device assembly, responsive to the transceiver.

10. The trackable playing device assembly as in claim 9,

wherein the physical characteristic of the playing device assembly altered by the means to alter comprises at least one of center of mass, center of gravity, moment of inertia, coefficient of friction, outer shape, roundness, and aerodynamics.

11. The trackable playing device assembly as in claim 7, wherein the active emissions is provided by at least one of a radio-frequency transmitter, a lightwave transmitter, and an audio transmitter.

12. The trackable playing device assembly as in claim 7, wherein the active emissions is provided by at least one of a visible light emitter, an infra-red emitter, and an ultra-violet emitter.

13. The trackable playing device assembly as in claim 7, wherein the active emissions means comprises an audible sound emitter.

14. The trackable playing device assembly as in claim 13, wherein the audible sound emitter emits at least one of a bird chirp sound, a bird song, a musical note, a sequence of musical notes, a ping sound, a beep sound, a siren sound, a portion of a show tune, a wildlife sound, a nature sound, a heartbeat sound, a celebrity voice, a preselected user sound, a user customizable recorded sound, and an echo of a nearby sound source.

15. The trackable playing device assembly as in claim 7, wherein the active emissions means comprises a low-level radio-isotope emitter.

16. The trackable playing device assembly as in claim 1, wherein the detectable signature comprises passive tracking means.

17. The trackable playing device assembly as in claim 16,

wherein the passive tracking means is excited by excitation means external to the playing device assembly; and

wherein the excited passive tracking means is detected by detection means external to the playing device assembly, responsive to the excitation.

18. The trackable playing device assembly as in claim 16, wherein the passive tracking means comprises a tuned reflective layer means for reflecting preselected wavelengths of incident electromagnetic radiation.

19. The trackable playing device assembly as in claim 18, wherein the passive tracking means comprises means to selectively perturb flux lines of at least one of a magnetic field, an electric field, and an electromagnetic field.

20. The trackable playing device assembly as in claim 1, wherein the detectable signature is encoded as one of a plurality of individual detectable signatures.

21. The trackable playing device assembly as in claim 1, further characterized for use within a detection and display system further comprising:

a detector subsystem for detecting the detectable signature;

a computing subsystem for determining the position of the playing device relative to the user's position, responsive to the detector subsystem; and

a user display apparatus, associated with the user's position, for providing a visual display of the playing device position relative to the user's position, responsive to the computing subsystem.

22. The trackable playing device assembly as in claim 1, further characterized as a golf ball.

23. The trackable playing device assembly as in claim 1, further characterized as one of a football, a soccer ball, a baseball, a softball, a puck, a frisbee, a volleyball, and a ball.

24. The trackable playing device assembly as in claim 1, further comprising a playing device tracking system for presenting to a user a position of the playing device assembly, the tracking system further comprising:

(a) sensing means responsive to the associated detectable signature means for sensing the signature output;

(b) computing means responsive to the sensing means for computing the position of the playing device assembly within the predefined region; and

(c) display means responsive to the computing means for providing a display presentation to a user of the position of the playing device assembly within the predefined region.

25. The system as in claim 24, wherein the sensing means senses the penetration of the playing device assembly into a plane of a play field scoring boundary.

26. The system as in claim 24, wherein the detectable signature means encodes one of a plurality of individual detectable signatures.

27. The system as in claim 24,

wherein there are a plurality of the trackable playing device assemblies, wherein each of the trackable playing device assemblies encodes a respective one of a plurality of individual detectable signatures;

wherein the sensing means further senses the plurality of individual detectable signatures; and

wherein the computing means further discerns between and computes the position of each of the trackable playing device assemblies within the predefined region responsive to the respective one of the individual detectable signatures.

28. The system as in claim 27, wherein each of the trackable playing device assemblies respectively encodes a unique different one of the plurality of individual detectable signatures.

29. The system as in claim 27, wherein each of the trackable playing device assemblies respectively encodes an identical same selected one of the plurality of individual detectable signatures.

30. The system as in claim 27,

wherein the display means is further responsive to the user; and

wherein the display means further provides a simultaneous display presentation to the user of the positions of each of a plurality of the trackable playing device assemblies responsive to the computing means.

31. The system as in claim 27,

wherein the display means is further responsive to the user; and

wherein the display means further comprises user selection means to select at least one of the plurality of computed positions for display to the user.

32. The system as in claim 31, wherein the user selection means calibrates the system to at least one user selected trackable playing device.

33. The system as in claim 24, wherein the display presentation is at least one of an audio presentation, a visual presentation, and an audiovisual presentation.

34. The system as in claim 24, wherein the display means is located remotely from the sensing means.

35. The system as in claim 24, wherein the computing means is located remotely from the sensing means.

36. The system as in claim 24, wherein the display means further provides a display presentation to a user of supplemental playing information.

37. The system as in claim 36 ,wherein the supplemental playing information comprises at least one of time, time remaining, quarter, inning, timeouts remaining, temperature, wind speed, wind direction, hole number, play field identification, elevation, inclination, distance to clubhouse, distance to rest room, distance to hole, air pressure, humidity, round number, cart number, game number, match number, set number, score information, penalty information, rule information, scorecard information, competitor status, club selection, club recommendation, messages, weather alerts, directions to nearest medical assistance, and advertiser information.

38. The system as in claim 24, wherein the sensing means comprises a plurality of sensors distributed at predefined locations relative to the predefined playing region.

39. The system as in claim 38, wherein selected ones of the plurality of sensors are buried below the predefined playing region.

40. The system as in claim 38, wherein selected ones of the plurality of sensors are elevated substantially above the predefined playing region.

41. The system as in claim 24, wherein the playing device assembly is a golf ball.

42. The system as in claim 24, wherein the sensing means senses at least one of radio-frequency signals, visible light signals, infra-red signals, ultra-violet signals, sound pressure waves, low-level radio-isotope signals, electromagnetic radiation signals, and perturbations in flux lines of at least one of a magnetic field, an electric field, an electromagnetic field, and a lightwave field.

43. The system as in claim 24, wherein

a detectable display signature is associated with the display means;

wherein the sensing means senses the detectable display signature relative to the predefined playing region;

wherein the computing means computes the position of the display means relative to the predefined region responsive to sensing the detectable display signature and associating of the detectable display signature; and

wherein the display means provides a display presentation of the position of the playing device assembly relative to the display means responsive to the computing of the position of the display means.

44. The assembly as in claim 1, wherein the trackable playing device assembly is constructed by the process comprising:

providing a detectable signature means;

providing a playing device conforming to the set of predefined physical characteristics; and

assembling the detectable signature means to the playing device producing a trackable playing device assembly;

wherein the step of assembling maintains the trackable playing device assembly's conformance to the set of predefined physical characteristics.

45. The system as in claim 44, wherein the assembling further comprises integrating the detectable signature means within the structure of the playing device.

46. The system as in claim 44, wherein the assembling further comprises applying the detectable signature means to the outer surface of the playing device.

47. The system as in claim 44, wherein the assembling further comprises applying a protective layer enclosing and protecting the detectable signature means.

48. The system as in claim 44, wherein the assembling further comprises:

applying a first protective layer enclosing and protecting the outer surface of the playing device; and

applying the detectable signature means to the outer surface of the first protective layer.

49. The system as in claim 48, wherein the assembling further comprises applying a second protective layer enclosing and protecting the outer surface of the detectable signature means.

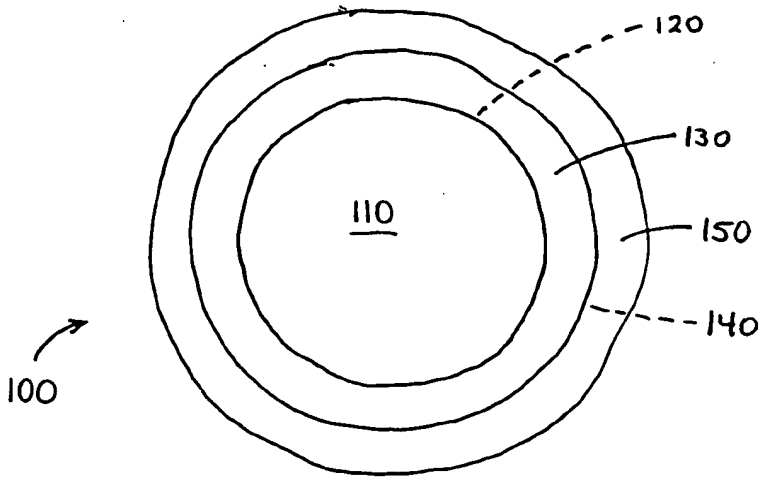


FIG. 1

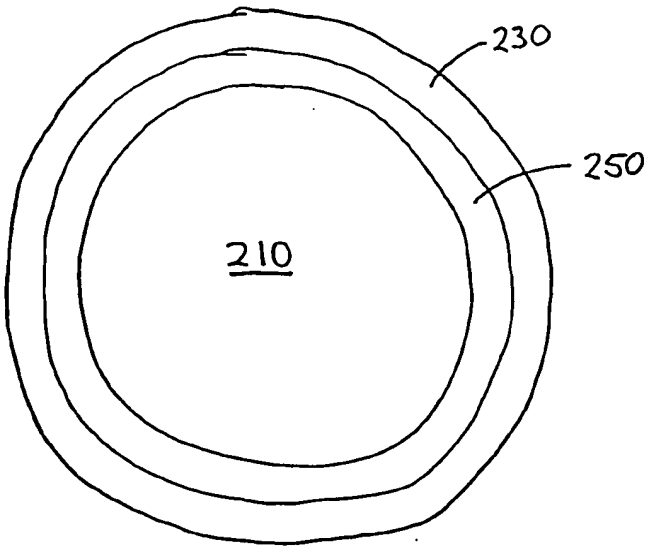


FIG. 2

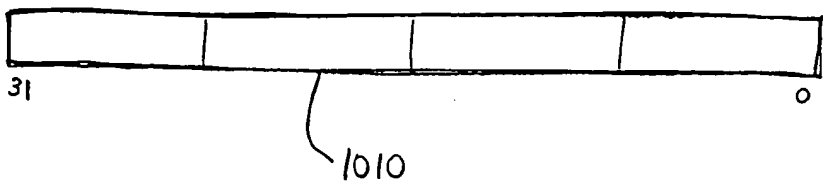


FIG. 3A

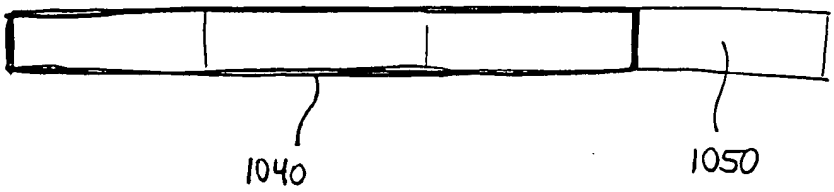
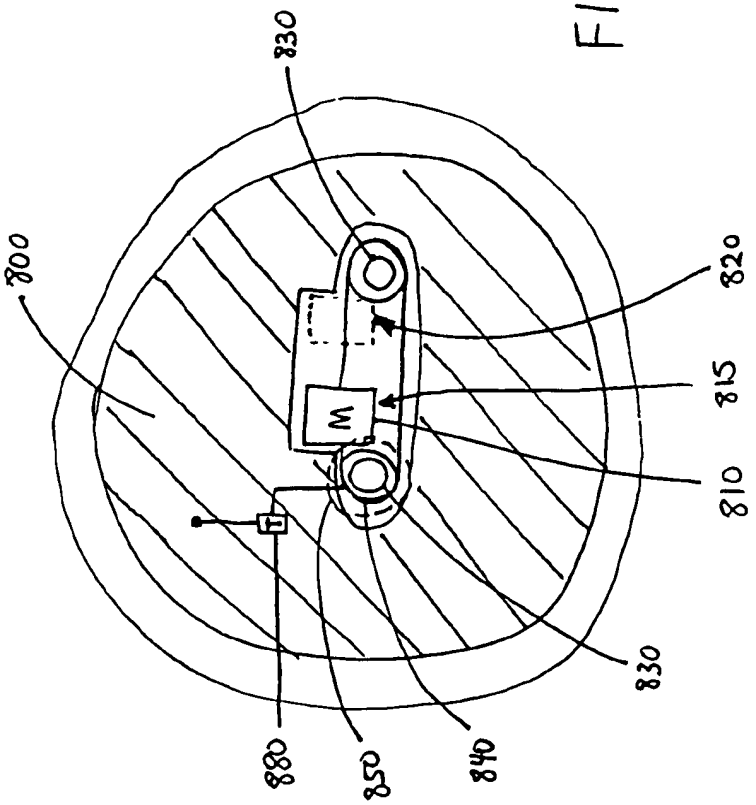


FIG. 3B

$f_1\ f_2\ f_3\ f_4\ f_5$	$f_1\ f_3\ f_4\ f_5$	$f_2\ f_3\ f_4\ f_5$	$f_3\ f_4\ f_5$
$f_1\ f_2\ f_3\ f_4$	$f_1\ f_3\ f_4$	$f_2\ f_3\ f_4$	$f_3\ f_4$
$f_1\ f_2\ f_3\ f_5$	$f_1\ f_3\ f_5$	$f_2\ f_3\ f_5$	$f_3\ f_5$
$f_1\ f_2\ f_3$	$f_1\ f_3$	$f_2\ f_3$	f_3
$f_1\ f_2\ f_4\ f_5$	$f_1\ f_4\ f_5$	$f_2\ f_4\ f_5$	$f_4\ f_5$
$f_1\ f_2\ f_4$	$f_1\ f_4$	$f_2\ f_5$	f_4
$f_1\ f_2\ f_5$	$f_1\ f_5$	$f_2\ f_4$	f_5
$f_1\ f_2$	f_1	f_2	

FIG. 4

FIG. 5



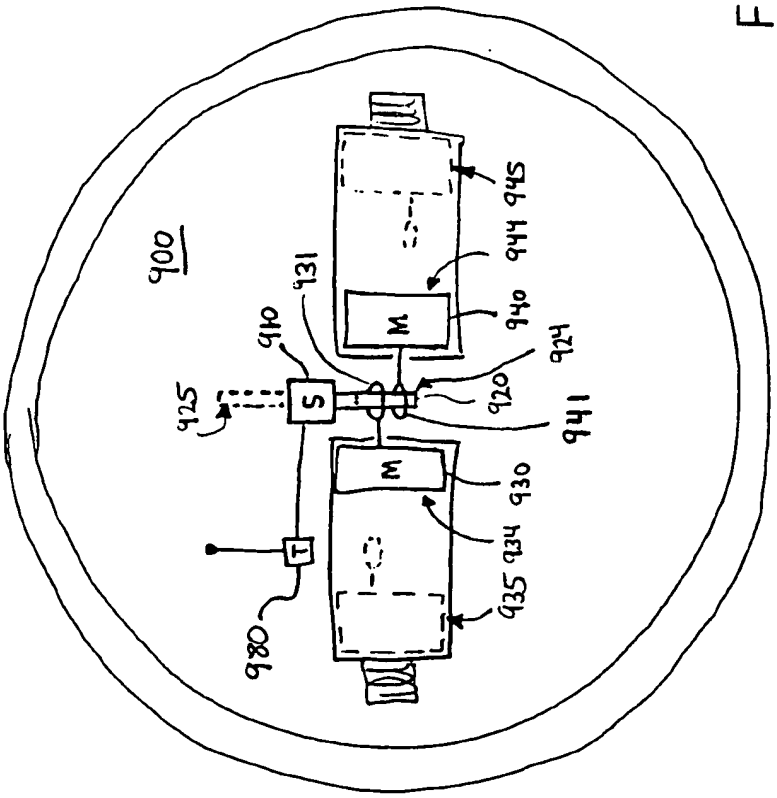


FIG. 6

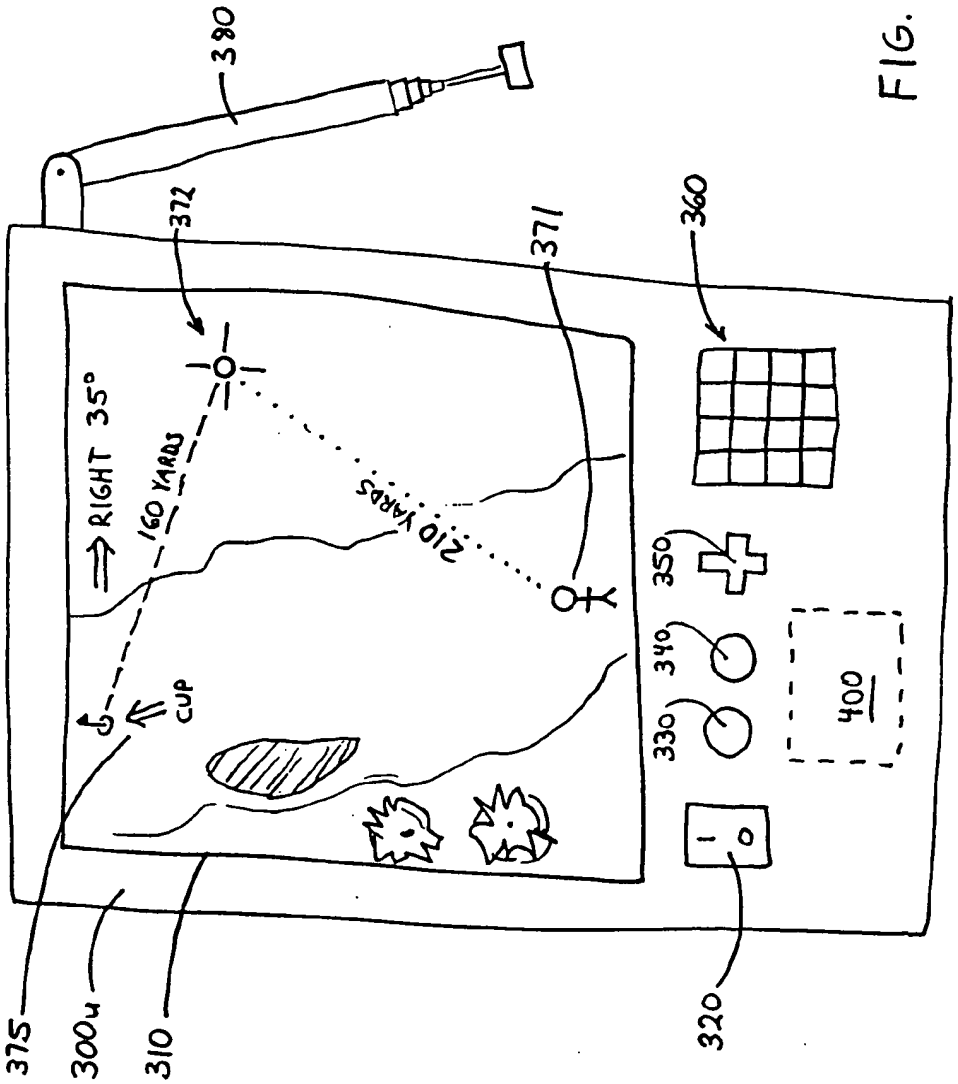

380
372
371
360
RIGHT 35°
160 YARDS
210 YARDS
CUP
350
340
330
400
1
0
375
300
310
320

FIG. 7

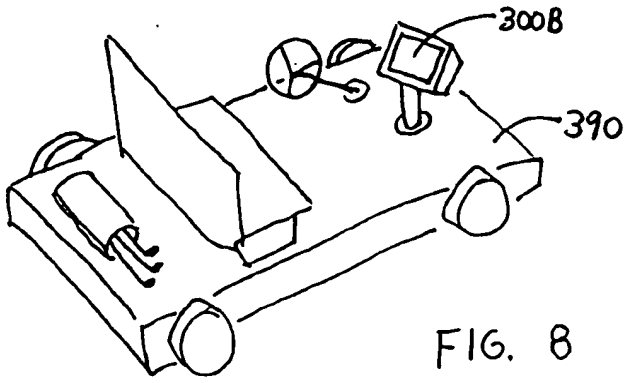


FIG. 8

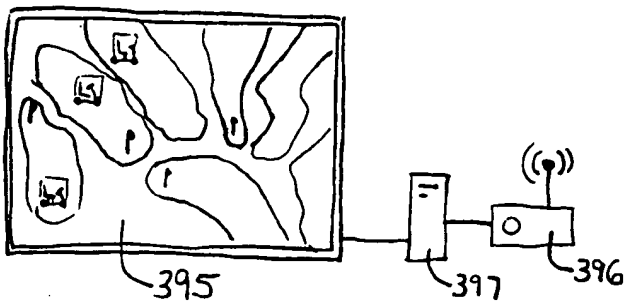


FIG. 9

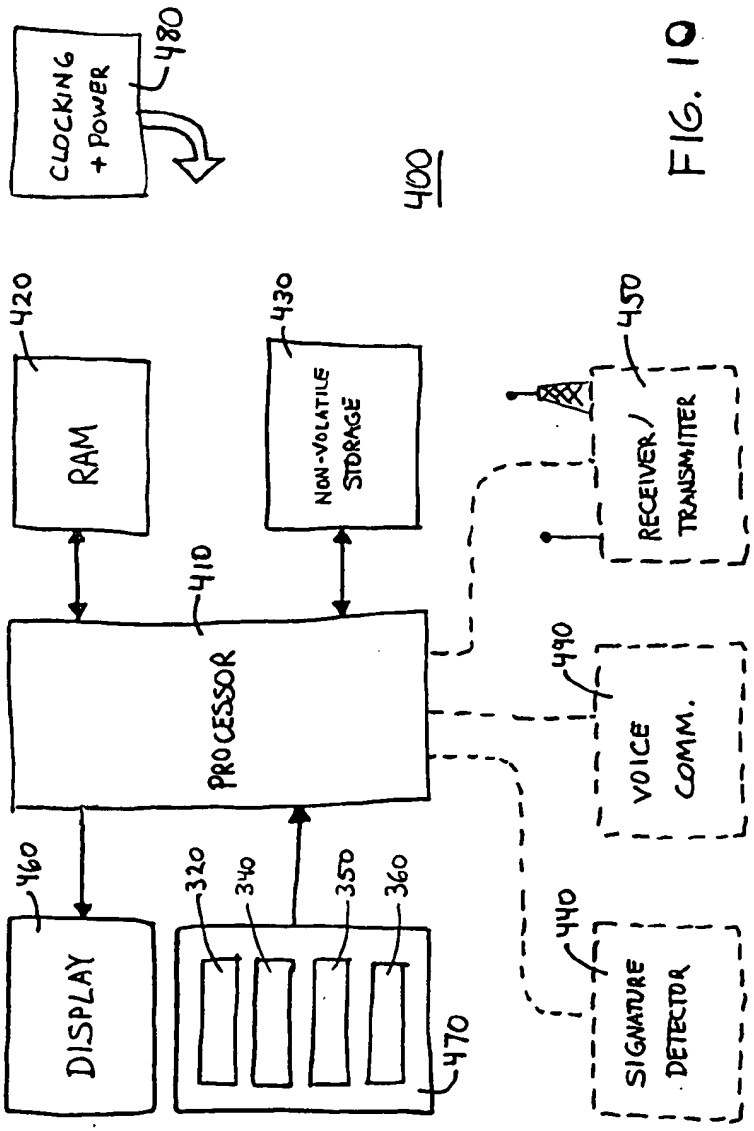

CLOCKING + POWER
480
400
RAM
420
NON-VOLATILE STORAGE
430
RECEIVER / TRANSMITTER
450
PROCESSOR
410
VOICE COMM.
490
DISPLAY
460
320
340
350
360
470
SIGNATURE DETECTOR
440

FIG. 10

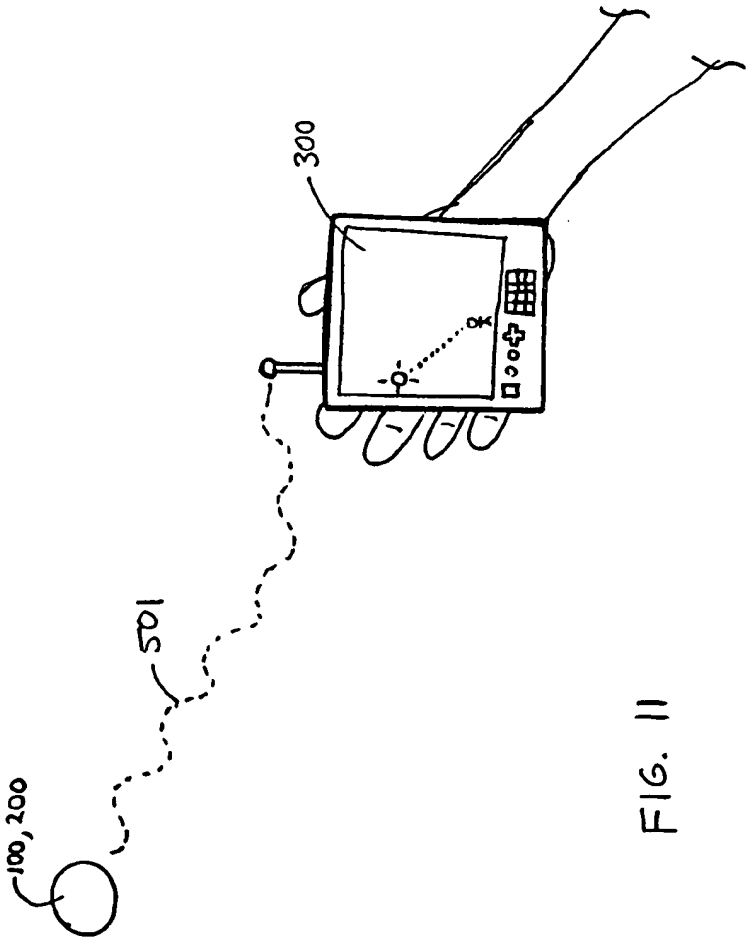


FIG. 11

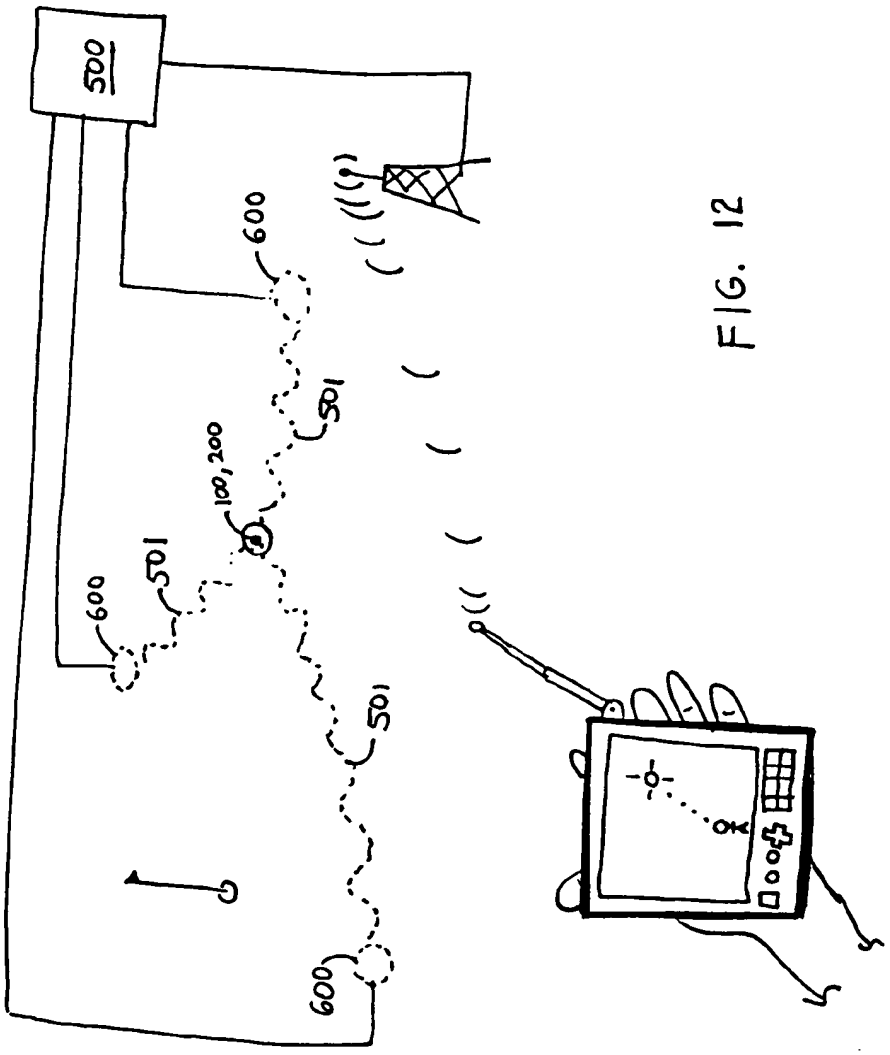


FIG. 12

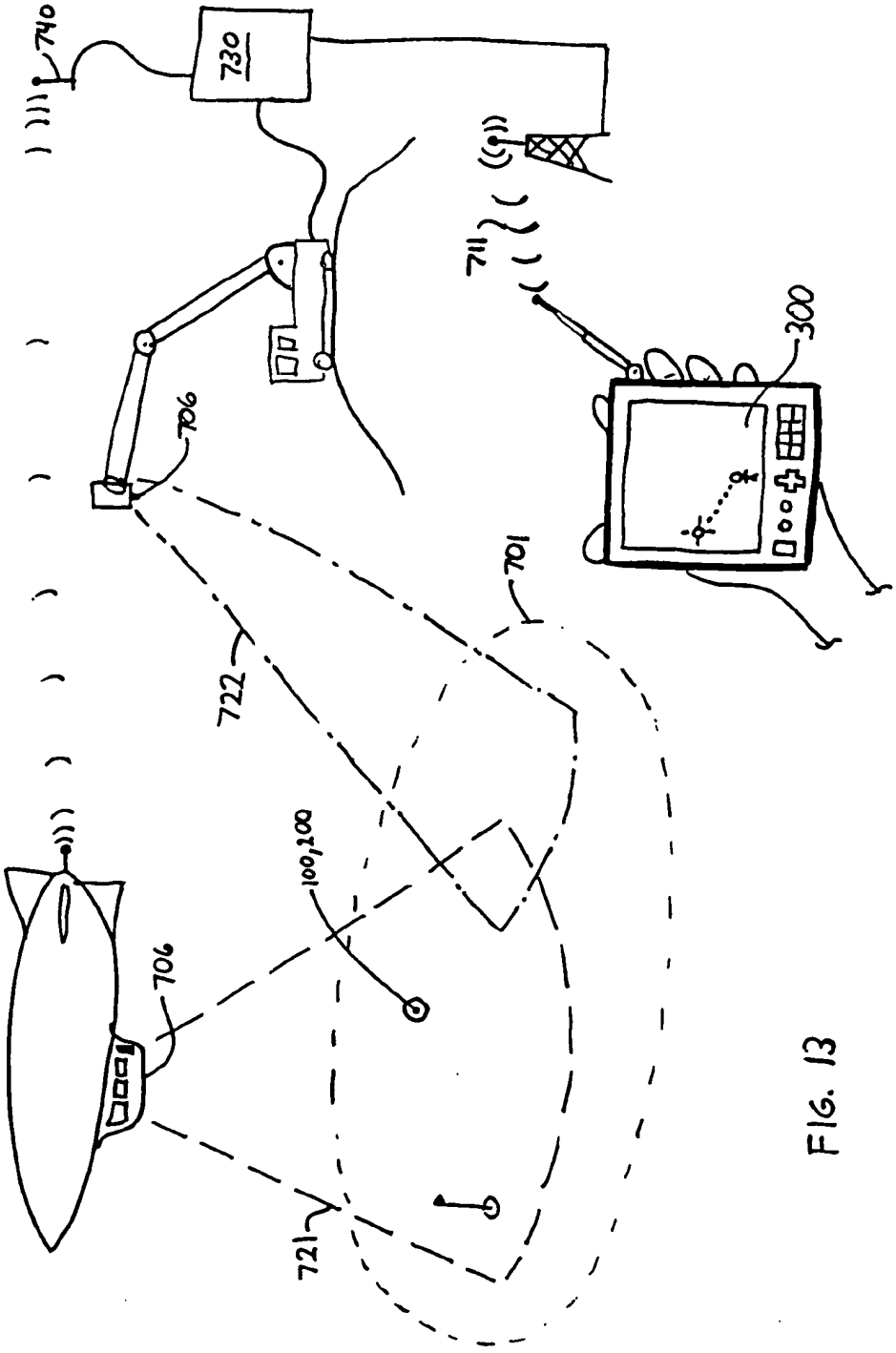


FIG. 13

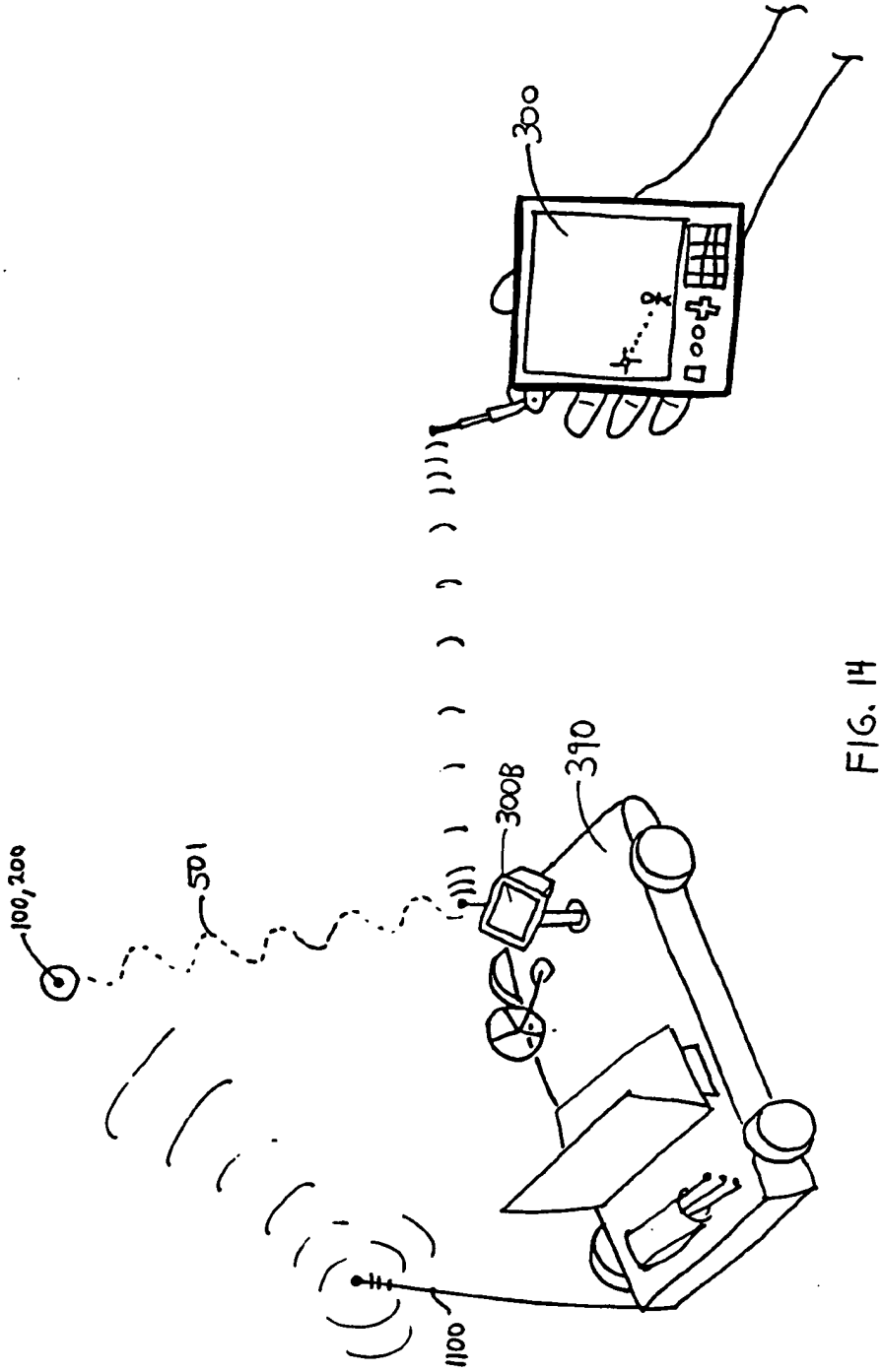


FIG. 14

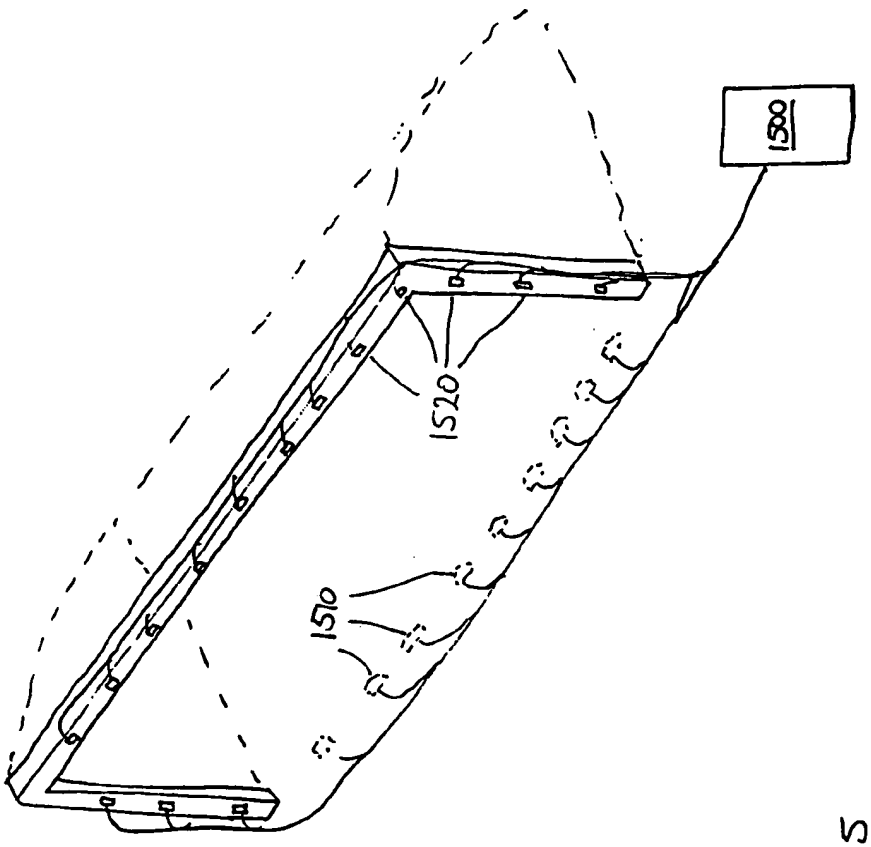


FIG. 15